Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2018-367-AC2, 2019

Interactive comment on "Bio-optical characterization of subsurface chlorophyll maxima in the Mediterranean Sea from a Biogeochemical-Argo float database" *by* Marie Barbieux et al.

Marie Barbieux et al.

marie.barbieux@obs-vlfr.fr

Received and published: 22 January 2019

We thank Reviewer #2 for his/her comments, our responses and description of any action taken in the revised manuscript follow each comment .

Having said this, I have a few concerns, which I thinks author should address. For example, though the authors have tried to explain the environmental factors that cause the presence of deep chlorophyll maxima, they have not explained the physical factors and their role. Much of their emphasis has been to relate the observations with parameters such as Par, Nitracline etc. I would like to include some description on the physical condition and variability in the MLD, thermocline etc. These factors also play a dominant role, particularly in defining the depth of nitracline or other nutrients distribution. The schematic explanation in figure 12 should also include the location (depth) of mixed layer and thermocline. I am not aware of the relation between thermocline and nitracline in Mediterranean sea but in tropical basins such as the Arabian sea, they are strongly coupled and one need to understand the variability in thermocline to understand the shape and depth of nitracline.

Response: We thank Reviewer #2 for this comment. We agree that the underlying physical controls of the SCMs are not extensively considered in our analysis. Therefore we made substantial modifications to our manuscript in order to account for Reviewer #1 and #2's comments. We chose to consider the Mixed Layer Depth (MLD) as it seems to be a more complete indicator of the physical processes than the thermocline. In addition both the MLD and the thermocline had very similar temporal evolution hence we decided to represent only the MLD on the different figures for a better readability. We represented the value of the Mixed Layer Depth (MLD) on Figure 5, on Figure 7 and on the schematic representation of the different situations of SCMs in the Mediterranean Sea during the oligotrophic summer period shown in Figure 12. We also analysed the difference between the MLD and the nutricline depth and reported this information on Figure 6e. Our results indicate that the summer MLD exhibits very similar values among the considered regions and that, on the opposite, the winter MLD shows significantly different values between the Western and Eastern Basins. Hence, we suggest that the different mixing regimes and subsequent nutrient supply to the surface layer of the ocean may explain the seasonal succession and the amount of typical shapes of SCMs in the various regions of the Mediterranean Sea. For example, in the Northwestern region of the Mediterranean Sea, substantial mixing occurs during the winter period (MLD deeper than the nitracline) inducing a seasonal renewal of the nutrients available in the surface and subsurface layers. In this region, 4 types of profiles of Chla and bbp are retrieved along the annual cycle and an SBM is observed during the oligotrophic period. On the opposite, in the Levantine Sea, the MLD is significantly shallower than the nitracline all year long, the upward diffusive flux of nitrates is weak and a SCM is systematically observed during the summer season.

To account for this comment, we modified the text in Section 3.1.3 (line numbers refer to the revised manuscript) as follows:

Âń To explore the light-nutrient regime within the SCM layer, a monthly climatology of the isolume and nitracline in the different considered regions was represented along with the depth of the Subsurface Chla and bbp Maxima (i.e. SCM and SbbpM, respectively). The MLD was also superimposed in order to illustrate physical forcings (Figure 5).

In the Western Basin, the isolume 0.3 mol quanta m-2 d-1, the nitracline 1 μmol, the SbbpM and the SCM were all located at a similar depth during the oligotrophic period (maximum depth difference < 20 m; Figures 5a-c). In accordance with previous findings (e.g. Pasqueron de Fommervault et al., 2015a), our results suggest that in the NW region of the Mediterranean Sea, the winter deepest climatological mixed layer depth reached the nutricline, thus likely inducing nutrient input to the surface layer.

In the TYR region, the MLD was always shallower than the nutricline during the winter season but the difference between the MLD and the nutricline remained very small all year long. Hence, in the Western Basin of the Mediterranean Sea both light and nutrient resources may be available at the level of the SCM to support an actual increase in phytoplankton biomass. In the Northwestern part of the Mediterranean Sea, the MLD was deeper than the nutricline $\sim$20% of the time during an annual cycle (Figure 6e) essentially during the winter season (Figure 5 a-c). The shallowest (median of 61 m; Figure 6c) and the steepest (slope of 90 μmol m-4; Figure 6d) nitraclines were also recorded in this region, thus confirming an important upward diffusive flux of nitrates available to sustain phytoplankton biomass and eventually allowed the occurrence of a Subsurface Biomass Maximum.

In contrast, in the ION and LEV regions, the isolume 0.3 mol quanta m-2 d-1, nitracline 1 μmol, SCM and SbbpM were not collocated in the water column (Figures 5d-e). The SCM was located $\sim$50 m above the nitracline during the stratified period (Figures 5d-e and 6a) and the SbbpM was shallower than the SCM (by $\sim$40 m), suggesting that the standing stock of carbon is maintained at a higher concentration above the depth of the SCM. In the Eastern Basin (Ionian and Levantine Sea), the MLD almost never reached the nutricline even during the winter period as it was deeper than the nutricline only <3% of the time during an annual cycle (Figure 6e).Âż (p. 17-18, l. 396-423)

We modified the text in Section 3.2 as follows:

Âń The mixed shape was characterized by a homogeneous distribution of Chla and bbp (as suggested by the deep mean MLD associated with this type of profile; Figures 7a-b) and showed occurrence exceeding 60% from December to March (Figure 8a). Âż (p. 21, l. 501-504)

Âń In the Levantine Sea, only two distinct shapes were encountered, i.e. the SCMaZeu and the SCMbZeu shapes and associated with shallow MLDs (Figures 7i-j). Âż (p. 23, l. 549-550)

We also modified the text in Section 4 as indicated below:

Âń 1) The SBMaZeu is a Subsurface Biomass Maximum that settles above the euphotic zone in the Northwestern Mediterranean Sea (NW). It is the thinnest ($\sim$40m) and shallowest ($\sim$60 m) biomass maximum. It is also the most intense, probably because it benefits from adequate light and nutrient resources, with the deep mixed layer occurring in this region during the winter period probably inducing a seasonal renewal of the nutrients in the surface layer.

2) The SBMbZeu establishes below the euphotic zone in the NW. As well as the SBMs of the Southwestern Mediterranean Sea (SW) and Tyrrhenian Sea (TYR), less intense than the SBMaZeu probably because nutrients conditions are less favourable than in

the NW region as the winter MLD is close to, but never reaches the nutricline.

3) The SCM of the SW and TYR as well as the SCMaZeu (i.e. settling above the euphotic depth) of the Ionian (ION) and Levantine (LEV) Seas are not biomass subsurface maxima, but reflect Chla maxima resulting from photoacclimation. Moving from the SW to LEV region, the amplitude of the SCM decreases while its thickness increases.

4) The SCMbZeu of the ION and LEV settle below the euphotic depth and are deeper (~95 m) than all the other subsurface maxima. They are most probably the consequence of a decoupling of the MLD and the nutricline and represent the oligotrophic end-member type of subsurface maxima in the Mediterranean Sea.Âż (p. 27-28, l. 644-660)

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-367, 2018.